THE GLASS INDUSTRY

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THE GLASS DIVISION AT THE A. C. S. ANNUAL MEETING

Papers at Technical Session deal with behavior and properties of glass the material, as being most useful approach to improvement in manufacturing. Plant trips and entertainment features forecast the most interesting meeting of any to date.

It has become the confirmed opinion of the leaders in American glass technology that the most useful advances in this field can be made by the study of the behavior and properties of glass as a material, rather than by more empirical studies dealing directly with manufacturing processes. The more progressive manufacturers are discovering that by this method some of the mysteries of glass melting and fabrication are beginning to clear up.

This attitude is again reflected in the program which the Glass Division has arranged for its technical sessions during the annual meeting of the American Ceramic Society, which is being held at the Waldorf Hotel, New York City, during the week of March 21. However forbidding some of the titles may sound and however irrelevant they may appear in the light of everyday glass making experience, each of the papers will play a definite part in making more secure the scientific foundations for better future results in the factory.

Those who work with the X-ray as a tool obtain for their immediate experimental results photographs, upon which appear concentric circles or arcs which are as definitely characteristic, for each crystalline compound through which the rays are diffracted, as would be its own chemical formula. These X-ray signatures, if we may call them such, yield amazing inferences. Even the glasses, although they are not crystalline, are beginning to disclose information through these X-ray photographs which is interpreted by the skilled investigator in such a way as to form a starting point at least for the explanation of a number of phenomena and behaviors not hitherto clarified.

Several of the papers in this year's sessions will deal with such interpretations. Professor Warren, of M.I.T., continues his studies of silica and soda-silica glasses. The question of structure is brought out for very definite discussion; in particular as to whether the silica in the glass has not somewhat the same arrangement of its ultimate ions as it does when it is in the form of cristobalite. Mr. Finn, of the Bureau of Standards, makes use of information obtained by Pauling on the ionic radii of the constituent oxides of a glass to gain at least an approach to a statement covering the relationship between composition and refractivity. This ought to be a very definite advance over the previous altogether empirical study of this relationship.

Taylor and Dear, of Penn State, in discussing elasticity, delayed elastic distortion, and viscous flow of several soda-silica glasses, make use of an ionic theory to explain these processes. Such an explanation would scarcely have been advanced a few years ago, before the swift progress of X-ray studies.

Annealing at different temperatures has been shown by Saunders and Tool of the Bureau of Standards to affect the expansivity of a glass by about 4 per cent. Annealing again comes into consideration in some of the comments by Weyl of Penn State on glass constitution.

A new method of studying durability (by studying solubility) of glasses will be handled by King of Ohio State. He has electrodialyzed glasses that have been previously tested for solubility by a number of investigators cooperating for The Glass Division. He has been able to show the rate at which the base — presumably soda — is released; and the whole paper should be an excellent critical study of the estimation of durability.

Undergraduate thesis work, while it can never be expected to do more than acquaint the student with the methods of research, and perhaps allow him to fix his interest at least temporarily upon some specialty, may nevertheless at times yield some results that are of interest, and that may point out where further study in more capable hands might uncover new and useful facts. Dr. Scholes of Alfred University will discuss a few of the theses offered there in the course in glass technology.

The strain finder is at once a useful and a misused and misunderstood tool in the glass factory. The peculiar effect of strained glass upon polarized light has not received much additional treatment since the days of Brewster, its discoverer. Dr. Mueller of M.I.T. now comes forward with a theory of photoelasticity, as this effect is known — at least in his institution. He has found that compression of a glass changes the distribution and arrangement of the atoms and gives rise to positive birefringence. This effect is greater for glasses having higher indices of refraction. The atoms are also deformed by pressure and this produces negative birefringence, and the effect varies little with composition. When the index of refraction is small, this second effect predominates and thus pressure causes most glasses and cubic crystals to show negative birefringence. It was found possible to select special glasses with index of refraction about 1.8 where the two effects compensated each other and no photoelastic effect could be observed.

Ellefson and Taylor of Penn State have launched into an interesting study of the problem of adherence of glass to metals, which might be called a study of wetting. By placing single drops of relatively low melting silicates,

● *Left: Dr. Robert B. Sosman, president-elect of the American Ceramic Society, and Francis Flint, retiring president.*

borates, and enamels on surfaces of noble metals and carbon, at high temperatures and in different atmospheres, some very entertaining results are obtained. The data are utilized for the study not only of wetting properties and adherence, but of the surface tension of the liquids themselves.

Taylor and his co-workers have made a study of the rate of diffusion of helium through annealed and unannealed glass in the temperature range from 200-600°C. They found no evidence of the so-called transformation point, and therefore doubt that this has any significance as to structure or constitution. Hydrogen was also employed as a diffusing material. The authors believe that diffusion takes place chemically and not through any sort of cracks or interstices in the structure. The gases go through the annealed glass more rapidly than through the strained glass.

Parmalee and Badger have continued their studies on surface tension, using the bubble-pressure method which they have previously used and described. Having developed this method, they are now in position to make use of it in studies on glasses of different compositions, and to estimate the effect of certain oxides on surface tension. It is likely that such work will go far in explaining some of the common phenomena of glass manufacture such as fire-polishing, edge glazing, the surface obtained when glass is pressed in a mold, and the comparative ease with which various glasses may be formed into shapes of circular cross-section.

Dr. Preston has made a mathematical study of the great variations obtained in experiments on measuring strength of glass. He discusses the "normal curve of errors" proposed by Gauss, and the necessity of determining experimentally how near the truth it may be. Since these mysterious variations in the strength of glass specimens that ought to be exactly alike are so baffling as to be irritating to anyone who has anything to do with the problem, much interest will attach to the report of this careful and capable physicist. Bailey and Lyle also are analyzing test data of tensile strength measurements, presumably more from the engineers' point of view.

In his comments on the constitution of glasses, Weyl of Penn State has selected a broad field. He will disclose methods for determining what goes on inside glasses in the way of producing dissociation and association, and how these processes are affected by temperature, heat treatment, and mineralizing agents. These matters have direct application to color problems, on which Dr. Weyl, is an authority, also to solubility of gases in the glass, and to the behavior of fibers.

A definite part of the technical sessions is given over to a symposium on the principal problems of glass technology now under investigation, and the first paper, on tensile strength tests, is by Dr. Littleton of Corning. These tests were made as part of the work of the Division's Committee cooperating with the American Society for Testing Materials. It will be of interest to all glass technologists to know that this work has now been made a definite part of the program of the A.S.T.M., and that a committee, C-14, headed by Dr. G. W. Morey, of the Geophysical Laboratory, has been formed to carry out tests of glass as a material of construction. While this does not eliminate any work which members of the Division may care to undertake, it will unify these efforts and make a specific place for glass in the reports of the American Society for Testing Materials, among other engineering materials, where it rightfully belongs.

As a piece of work subsidiary to that of the Division committee above referred to, Scholes will report on thermal endurance. His results seem to indicate the very striking effect of annealing and disannealing upon thermal endurance, and therefore the futility of making thermal shock tests upon specimens whose heat treatment is not certainly known. The somewhat startling result, that half-inch rods of lime glass will endure about twice as much cooling shock in their original unannealed condition as they will after annealing, serves to emphasize this point. James Bailey, expertly critical as always, will point out that tests for thermal endurance of glass must necessarily be inconclusive, unless they are applied to specimens of precisely the same shape and size which have undergone precisely the same heat treatment.

The problem of hardness comes up for discussion in the hands of Dr. Tuckerman of the Bureau of Standards. In the factory, hardness may mean, to the man in the finishing room, the difficulty with which his blown ware is scored with a diamond and cracked off by the flame; to the plate-glass grinder, it may mean resistance to abrasion; to the maker of bottles, permanence of surface; and to the ultimate user of glass it means its resistance to scratching or fracture. It is to be hoped that this paper and the discussion which is bound to follow will clarify the term "hardness" or suggest some other word more sharply defined and more precisely descriptive.

The Glass Division is closely related to certain other technical societies; and its work, so far as it relates to the needs of the Illuminating Engineering Society, will be discussed by Dr. Blau, of Macbeth-Evans Glass Division, Charleroi; R. A. Miller, of Pittsburgh Plate Glass Co., will speak on the Division's work as it relates to the Society of Heating and Ventilating Engineers; while Dr. Taylor of Corning, Head of the Division's Committee on Specifications and Tests, will say how we are related to the American Society for Testing Materials. These discussions may well be expected to point to the Glass Division as the logical clearing house and correlating agency for all work on glass. They may also show where much duplication of effort may be avoided, where experimental data may be exchanged, and where new problems may be introduced that will be of specific importance to the engineering profession.

Since there has been some discussion as to the character of the programs of the Glass Division and some expression of desire that these programs should fairly represent the needs and interests of two distinct types of members, it is likely that a proposal will be brought forward for a change in the tenure of office of the official staff. It may be thought desirable to provide for an assistant to the Vice-chairman in charge of programs who, perhaps after serving a year in this position, will automatically become Vice-chairman, and at a third election, Chairman of the Division. This officer, under the proposed plan, would be selected in alternating years first from the group of members concerned directly with plant production and second from among those more directly concerned with research and scientific study of glass. Under this plan, which is the suggestion of Chairman Gregorius, it is pointed out that we would have the benefit of accumulated experience in the official staff, so that by the time he is elevated to the office of Chairman, a man would be well acquainted with the operation of the Division. Furthermore, the program for any year would be in the hands of two men of differing special interests, who could be depended upon therefore to solicit and provide for papers which would adequately cover the interests of both the groups mentioned.

This plan of changing the organization is likely to bring up animated discussion. It might be argued for the plan that the definite inclusion of a number of papers dealing directly with manufacturing matters would be much more attractive to the plant men, and that, after all, a large part of the cost of operating the Division, as of the Society itself, finally falls upon those actually engaged in manufacture, and that they are therefore entitled to such consideration. An opposing view may well be expressed by saying that the present high status of the papers and discussions in the Division meetings may be attributed to the fact that for several years past we have leaned definitely to the scientific side and that we are thereby producing results which slowly but surely will work through to the industry and change it for its permanent benefit. It may also be pointed out that discussion of plant technique may well take place between individual members, and that many of the problems involved are not such as would lend themselves to the open-airing of the technical session.

A non-technical paper which is, nevertheless, welcome on the program, is a review of the life and work of Le Chatelier, by Dr. Silverman of Pittsburgh. Le Chatelier, who was an honorary member of the American Ceramic Society at the time of his death last year, made such important fundamental contributions to our scientific methods and data that we may well pause to honor his memory and to become better informed about his achievements. Dr. Silverman will also appear before the Division at one of the luncheon meetings and show some of the colored motion pictures for which he is justly noted among his friends. Prominent among these pictures will be those of the group attending the meeting at Cambridge Springs. It is hoped that Dr. Silverman will also include pictures from the collections which he has taken during his travels in Europe.

In addition to the papers devoted primarily to the Glass Division, many other addresses of general interest to glass men are offered. First of these is the President's Address by Francis C. Flint of the Hazel-Atlas Glass Co., who has enjoyed a most successful year as head of the Society. J. B. Vail will speak authoritatively, March 22, on "Perspective in Relation to Research." G. W. Morey of the Geophysical Laboratory will follow him with a paper entitled "Silica Science."

The various other Divisions will also offer much of interest to glass technologists. In the Materials and Equipment Division, R. W. Stone, advanced geologist of the Commonwealth of Pennsylvania, will report on the glass sand industry in Pennsylvania in 1936. In the Refractories Division two particularly pertinent papers are scheduled: W. W. Winship on "The Refractory and Ceramic Uses of Fused Silica," and H. M. Kraner on "Some Considerations in the Process of Producing Fused Mullite for Refractories." In the White Wares Division, A. C. Hardy's paper, "Physical Aspects of Color and Its Measurement," may offer many suggestions applicable to color in glass. Another talk of general interest will be delivered by Alice King on her experiences in studying exactly what Mrs. New York looks for when she is shopping for ceramic ware.

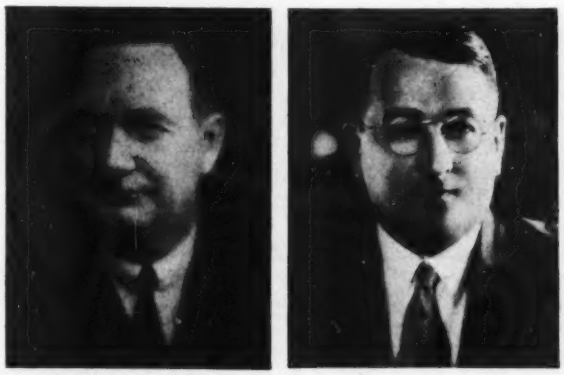
The Orton Memorial Lecture will be delivered Tuesday night by Dr. Robert B. Sosman, president-elect of the A. C. S., who has chosen "Pyrometry and Steel Makers Refractories" for his subject.

Perhaps, the most outstanding feature of this meeting in New York is the tremendous opportunities which it offers for an inter-change of ideas. Typical of this is the visit which a group of 26 German ceramists (members of the Deutsche Keramische Gessellschaft) will pay to the convention on Sunday and Monday previous to starting on plant trips throughout the Eastern and Mid-Western sections of the United States.

Plant Trips In and Near New York City

A comprehensive schedule of plant trips for all divisions has been planned for Friday, March 26. Members of the Glass Division will leave the Waldorf at 7:30 in the morning en route to several glass plants in New Jersey. First stop will be Bridgeton, where the visitors will be guests at luncheon, at the Hotel Cumberland, of Owens-Illinois, Kimble and Whitall Tatum. From here, the group will travel to Vineland and Millville and then back to New York, leaving Millville at about 4:00 P.M.

The Whitewares Division will spend Friday in Trenton, N. J., visiting four different plants, while the Enamel Division will concentrate its visits in New York, except



● *Left: Victor V. Kelsey, vice-president-elect and C. Forrest Tefft, treasurer elect.*

● *Left: C. E. Bales is on the Board of Trustees from the Refractories Division. Right: Ross C. Purdy, general secretary.*

for a trip to Camden, N. J., Thursday afternoon. Expeditions to Woodbridge and Perth Amboy, both in New Jersey, are being planned for the Refractories Division. Tickets for each of these trips will be available at the A. C. S. registration desk on Monday morning, March 22.

Unusual and Varied Entertainment Planned

Needless to say, all of the entertainment facilities of the greatest metropolis in the world are being thrown open to members of the American Ceramic Society, their wives and friends. On Sunday evening, Commissioner Moss, in behalf of official New York, will welcome delegates to the City and proclaim Ceramic Week.

Commissioner Moss' welcome will be presented during the President's Reception, when Francis Flint will deliver his address. A feature of this Sunday's evening will be the International Choir who will present a veritable League of Nations of harmony. In addition to the chorales there will be individual renditions by capable soloists, including Eleanor Bate, a harpist of distinction.

The Big Get Together of the Convention will be Monday night, when, in the words of the Circus impressarios, "a veritable galaxy of youth and beauty will be gathered under a single roof." After cocktails, there will be a dinner served in the beautiful Jade Room. Then to the Grand Ball Room for a truly amusing floor show. 16 beautiful girls, featuring a jazz toe dancer. Zingo, the marvelous horse. A revue typical of la vie Parisienne.

A distinguished guest at this soiree of ceramists and their ladies will be Lowell Thomas, one of the world's most able news commentators. Mr. Thomas will, no doubt, be able to present something of the problems facing a harrassed world. He is scheduled to speak at 9:45, and promises a real treat.

Following him will be the entertainers referred to in an earlier paragraph. After this there will be general dancing, which all (it is hoped) will join in to celebrate a really great gathering. James Caruso's 12 piece band will supply the inspiration for ceramist's terpsichorean fancies.

Again, on Wednesday night, the wild bells will ring out. To begin with, it will be "Broadcasting Night." (Stop at the Registration Desk of the A. C. S. for your tickets.) For one, Du Pont has offered "The Cavalcade of America" to the convention, featuring the life of a most famous early American ceramist "Henry William Stiegel." Then there will be a movie, "The Wonder World of Chemistry," before starting off toward the French Casino.

An entire block of tickets is on reserve—and will be at the Registration Desk until noon Wednesday—for the A. C. S. Lucius Beebe, who knows his New York, says the French Casino is "tops."

Thursday night, there will be the drama—in a light vein. Tickets for "Brother Rat," one of the outstanding hits of the season, have been secured at greatly reduced rates. The play doesn't deal with Mickey Mouse. It's a satire—very funny and gay—of life among the students at a military academy.

For Friday night—it follows the extensive plant trips that day—nothing is planned. Saturday noon some members of the A. C. S. will be sailing for the West Indies for a week's holiday.

The Ladies—May They Be Entertained

In addition to the general entertainment planned, special attention has been given the ladies. To begin with, there will be a Bridge Tournament, Monday afternoon, with highly desirable prizes of ceramic ware. They—the prizes—have been contributed by leading glass and ceramic companies, and are so attractive that they will be displayed in the main lobby of the Waldorf-Astoria during the sessions.

Tuesday morning, the ladies will have the pleasure of "snooping around" New York. Shopping or seeing the things they want to see.

Tuesday afternoon, that really beautiful ship, the SS *Queen Mary* will be open to the ladies. This is a real treat, for "the Queen" is never open afternoons to the general public. There will be a guided tour through the ship—or you may browse about. (Incidentally, the men will also be most welcome.)

Then, on Wednesday morning, there will be a tour of New York by bus. It shows you an organized view of New York—the things you might miss otherwise. Back to the Waldorf. Then by taxi to Radio City for lunch. The afternoon is devoted largely to a tour of Radio City.

There's Macy's on Thursday morning. It will be a conducted tour with guides who know what the ladies will like to see. Then, after luncheon at the Waldorf, to the world famed Planetarium and the New York Museum of Natural History.

All in all, the 39th annual meeting of the A. C. S. has been a tribute to those who spent unconsidered hours in making it a meeting of varied interests. The ladies have been served—the gentlemen have been entertained—the technologists have spoken. The scientific and the practical side of glass passes another milestone.

CHEMICAL INDUSTRIES EXPOSITION

The 16th Exposition of Chemical Industries will be held at Grand Central Palace, New York, Dec. 6-11, 1937. Three floors of Grand Central Palace have been reserved and advance leasing to date indicates that the 1937 exposition will be one of the largest in recent years. Indications at this early date point to an exposition in which the role of chemical industries in the great reconstruction period now under way will be emphasized through the medium of dynamic displays designed to show the coordination of each phase of chemical manufacture with the many industries to which it is related.

THE CHEMISTRY OF COLORED GLASS[1]: II

By DR. ING. WOLDEMAR WEYL[2]

• *Following is the second instalment of Dr. Weyl's study on the chemistry of colored glasses. It covers several important oxides and their oxidation-reduction equilibria. The first instalment published in March was of an introductory nature and covered the origin of the absorption spectrum and its changes under the influence of the solvent as well as present dissociation-association equilibria between coloring complexes. In the May issue, Dr. Weyl will discuss the mutual interaction of coloring oxides of different valencies among each other and with arsenic oxides. At that time, he will also consider the possibilities of developing new colorants.—The Editor.*

2. Some Important Oxides and Their Oxidation-Reduction Equilibria

The effect of the state of oxidation of different metals upon their ionic colors is best known; many details have been studied for glasses. In contrast to the effects already mentioned — solvation of ions, dissociation and association of molecular complexes with different coordination numbers (which can be detected optically but not by chemical means) — the state of oxidation may sometimes be investigated by analytical methods. Taking into account the great difficulties in the study of glasses by these methods, the optical methods are also of advantage here, and often supersede in accuracy the chemical methods. The chromium glasses will be chosen as an example in the discussion following.

Chromium glasses—It has been previously known that glasses containing chromium oxide show variations in color. Depending upon the composition of the base glass, the melting temperature, and the nature of different additions, the color shows all transitions from a pure green to yellowish green, brown, and even orange. K. Fuwa, to whom we are indebted for a series of valuable observations on glass colors and their dependence upon the composition of the base glass, supposed that the yellowish tint of some chromium glasses is due to the presence of chromates. Hence, an equilibrium probably exists between trivalent and hexavalent chromium, i.e., between chromic and chromate compounds. Under extreme reducing conditions, it is even possible to obtain divalent chromium compounds in glass, and these are blue.

Chromic compounds are slightly soluble in glass and hence, during cooling, glasses containing higher amounts of chromium precipitate the latter in the form of hexagonal plates which form the chromium aventurine. Considering the low chromium content of ordinary glasses, it would be practically impossible to study these interesting equilibria and the way in which they are shifted by the melting temperature, glass composition, and furnace atmosphere by analytical methods. Therefore, these glasses have been studied optically by resolving the spectra into two parts which may be attributed to the trivalent and hexavalent chromium respectively. This has been done in the following way: The presence of hexavalent chromium may be avoided by choosing a base glass such as boric acid or glassy phosphoric acid where there is no basic component present. Under these conditions, the formation of chromates is impossible. For glasses in which chromates may be formed, the addition of 1.5 per cent As_2O_3 or Sb_2O_3 to the batch is sufficient to reduce the chromate to trivalent chromium. Emerald green glasses could be prepared by either of these methods. The absorption spectrum is shown in Fig. 16. The same figure also shows the spectrum of a similar chromium glass melted under oxidizing conditions.

Two main differences are apparent. If the glass is melted under reducing conditions, instead of slightly oxidizing conditions, the extinction of the band at 650 $m\mu$ increases from 0.63 to 0.79. Furthermore, the absorption edge in the blue is replaced by an absorption band in the shorter wave length region, the maximum of which is at 450 $m\mu$. The shape of an absorption curve of a chromic glass is very similar to that of an aqueous solution of a chromic salt. Fig. 17 shows the absorption of the bluish and greenish chromic sulfate in aqueous solution. It is a general rule that the absorption band of a cation in glass occurs at longer wave lengths than the absorption band of the cation in aqueous solutions. The increase in height of the band at 650 $m\mu$ by melting the glass under reducing conditions indicates that the amount of chromic oxide has increased at the expense of the chromate. Assuming that the chromate itself does not absorb light in the region of 650 $m\mu$, the chromic-chromate equilibrium can be calculated from the extinction at this wave length. If the glass has been melted under oxidizing conditions, $\frac{0.63 \times 100}{0.79} = 81$ per cent of the chromium is in the trivalent state, and hence 19 per cent in the form of chromate. To prove that the chromate does not absorb light in the region of 650 $m\mu$, a yellow chromate glass has been melted and examined. Pure chromate glasses can be prepared by fusing together

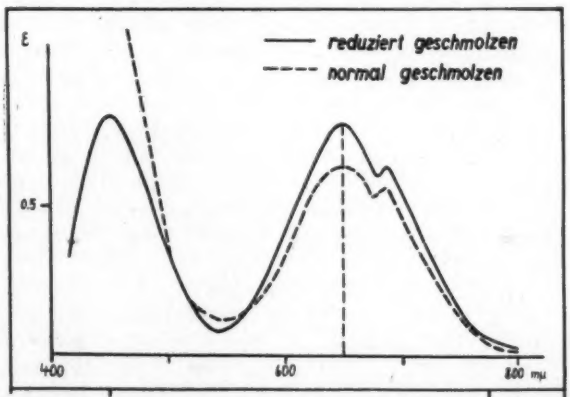


Fig. 16. Absorption spectra of chromium-sodium-silica glasses. Broken line indicates molten under oxidizing conditions. Unbroken line indicates molten under reducing conditions.

[1] A comprehensive bibliography concerning the mechanism of color formation, was published by F. H. Norton, THE GLASS INDUSTRY, Feb., 1935.

[2] Head of the Dept. of Glass Research, K.W.I. für Silikatforschung, Berlin-Dahlem. For the year 1936-1937, Associate Professor of Ceramics, The Pennsylvania State College.

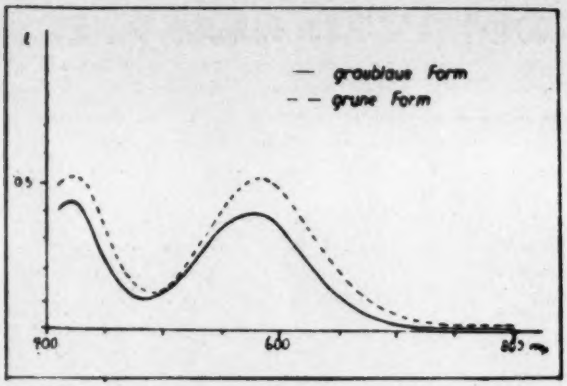


Fig. 17. Absorption spectra of chromium sulfate in aqueous solutions. The unbroken line shows the hydrate isomers in bluish form. The broken line shows the hydrate isomers in greenish form.

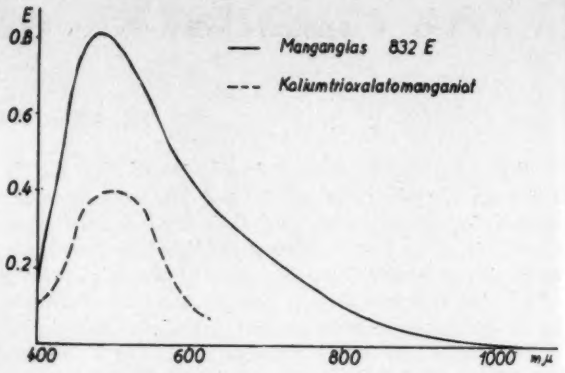


Fig. 18. Absorption spectra of trivalent manganese in glass and in aqueous solution. Unbroken line shows manganese glass and the broken line shows a potassium-manganese-oxalate.

a sodium silicate glass and an alkali chromate under an oxygen pressure of about 250 atmospheres. It is found that the characteristic absorption of a chromate glass is in the ultraviolet and only a sharp absorption edge extends into the visible. Indeed, a chromate glass, like an aqueous solution of an alkali chromate, does not show light absorption at 650 $m\mu$.

After having established a method for determining the chromic-chromate equilibrium in glasses, there was no further difficulty in examining quantitatively the influence of different factors upon the position of this equilibrium. The results are summarized as follows:

1. Other conditions being kept constant, the equilibrium is shifted toward the side of chromic oxide with increasing melting temperatures.

2. The position of the equilibrium depends upon the composition of the base glass. Acid melts favor the trivalent chromium and basic melts, the hexavalent chromium. Potassium glasses behave more basically than sodium glasses of corresponding molecular composition. Lead oxide and barium oxide stabilize the chromate.

3. Glasses containing chromate are very sensitive to reducing conditions such as furnace atmosphere or additions to the batch such as arsenic and antimony oxides.

4. The absorption edge of the chromate in glasses containing boric oxide is shifted toward longer wave lengths; the color therefore becomes darker, i.e., more olive green.

Manganese glasses—Considerations similar to those discussed for chromium oxides can be extended to other coloring oxides. For manganese glasses, it was also necessary to study the two states of oxidation separately. The color due to divalent manganese can only be observed in glasses containing relatively high concentrations of MnO. A glass containing 10 per cent MnO is yellowish brown and has an absorption band in the violet region. However, the glass industry is interested only in the deep purple color of trivalent manganese which is quite stable in glass as compared to its behavior (the very unstable ion) in aqueous solution. Fig. 18 shows the absorption of a manganese glass and that of an aqueous solution containing trivalent manganese in the form of a more stable complex ion; both have an absorption band in the green region of the spectrum.

The purple color of managanese glasses is sometimes said to be due to the formation of permanganates and, as a matter of fact, the color of a permanganate solution appears to be very much like that of a manganese glass. However, the spectra show a distinct difference. The curve due to permanganate ion in aqueous solution shows a remarkable degree of fine structure, consisting of some rather sharp bands. Comparing the colors of ions in aqueous solutions and in glasses, it is usually found that the bands in the latter case are sharper than in the former. It therefore seems unreasonable to attribute the purple managanese color in glass to the existence of permanganates.

In order to draw further conclusions concerning the equilibrium between Mn^{++} and Mn^{+++} in glass, it was necessary to determine the absorption of a glass containing only Mn^{+++}. Such a glass could be obtained by melting sodium silicate with 0.1 per cent MnO under an oxygen pressure of 250 atmospheres. Once the absolute value of the extinction was determined for trivalent manganese, the oxidation-reduction equilibria in other manganese glasses could be calculated in a manner similar to that described for chromium. It has been found, for example, that a glass containing 4 per cent MnO melted on a commercial scale contains only 0.1 per cent of its manganese in the trivalent form. A satisfactory explanation of the pronounced effect of reducing agents on the purple manganese color in glasses is offered by the fact that only a very small amount of trivalent manganese is really responsible for the color.

The position of the absorption band due to trivalent manganese in glass is influenced to some extent by the degree of solvation of base glass and upon the temperature. These factors have already been discussed in detail in a previous section.

Iron glasses—Of all the coloring oxides which occur in glass, the iron oxides are without doubt the most important. To a greater or lesser extent, iron is introduced into every glass batch in the raw materials, especially in the sand. Our interest in iron as a colorant is a negative one, that is, every effort is made to avoid and to mask the color due to it. This can be done by two essentially different means. One is a chemical process in which the ferrous-ferric equilibrium is shifted toward the ferric which is less strongly colored. The other process is a purely optical one and is often referred to as "physical decolorizing." It consists in neutralizing the greenish iron tint by a pink colorant, usually selen-

ium, manganese, or neodymium. Since this "physical decolorizing" actually decreases the amount of light transmitted through the glass, it is not used in the manufacture of optical glass.

In order to understand these problems, it is necessary to know the behavior of iron oxides in glasses. As a result of the fundamental researches of Hostetter, Roberts, and Sosman, it is known that ferric oxide which is introduced into a glass tends to dissociate into ferrous oxide and free oxygen. The equilibrium between the two oxides depends upon many factors, such as the melting temperature, the concentration of iron in the base glass, the composition of the base glass, and the furnace atmosphere. The melting time is also of paramount importance, inasmuch as we often deal with non-equilibrium conditions in glass, brought about by the fact that the viscosity rapidly increases with decreasing temperature. It is therefore seen why prolonged or repeated heating or using too much cullet imparts a bluish color to the glass.

Pure ferric glasses can be obtained under high oxygen pressures. These glasses are yellowish brown. Their absorption is very similar to that of an aqueous solution of ferric chloride. Ferrous glasses have a blue color due to their absorption band in the infra red which partly extends into the long wave length region of the visible.

In a later section of this paper, the influence of manganese, cerium, and arsenic on the ferrous-ferric equilibrium will be treated.

Vanadium glasses—Vanadium is one of the rarer colorants. Its oxidation-reduction equilibrium between V_2O_3 and V_2O_5 is similar in its color production to that of Cr_2O_3 and CrO_3, except for the fact that in the former case the equilibrium is shifted more to the side of the higher oxide. V_2O_3 gives rise to a green color, V_2O_5 to a brownish yellow.

The formation of V_2O_5 in a glass causes a strong absorption in the ultraviolet. This property makes these glasses very desirable for use in the manufacture of goggles and other eye protecting glasses. Just as for the chromium glasses, here also the oxidation-reduction equilibrium is influenced by the furnace atmosphere, melting temperature, and the acidity of the base glass.

In certain cases, there is a possibility that divalent vanadium may also be formed in the glass. According to an observation of H. Löffler, glasses containing both vanadium and cerium oxides, develop a pink color when exposed to daylight. This pink color is probably due to the divalent vanadium ion which also occurs in aqueous solutions of vanadium salts in the presence of strong reducing agents.

Uranium glasses—Uranium is the heaviest element in the sixth group of the periodic table, of which chromium is the third. Uranium is usually introduced in glasses as the yellow uranium oxide, that is as $Na_2O.2UO_3$, the sodium salt of the acid oxide UO_3. In addition to UO_3 there exists another well known uranium oxide, namely UO_2. This latter oxide has basic properties and forms the uranous salts when treated with acids. In a glass containing uranium, both states of oxidation may exist. The equilibrium depends upon the same factors which have been emphasized for chromium and vanadium glasses.

Fig. 19 shows the absorption behavior of a uranium glass. The most pronounced absorption is in the ultraviolet. This is why uranium is sometimes used for goggle glasses. Under reducing conditions, dark green or brownish glasses are obtained, containing the uranium in a lower state of oxidation. The absorption spectrum of such a glass (Fig. 20) is very similar to that of an aqueous solution of a uranous salt. These uranous glasses have no technical importance, for their color is rather dull. However, they are sometimes used as green filter glasses, showing typical band absorption.

The higher oxide, UO_3, is amphoteric, that is, it exhibits both acid and basic properties. In basic glasses it forms uranates, as, for example, in glazes which are rich in lead oxide. In this case the well known tomato red, lead uranate, is formed. With acids, UO_3 forms a series of salts called uranyl salts. These contain the stable uranyl ion $UO_2{}^{++}$, and have a yellow color. Many uranyl salts are characterized by their strong fluorescence in the green. In glasses, the presence of uranyl compounds also causes a characteristic fluorescence. However, glasses which contain the lower oxide (uranous compounds) or the oxide UO_3 in the form of uranates do not show fluorescence.

One of the most characteristic properties of glasses containing uranium is the fluorescence. However, other ions in glass also give rise to this phenomenon. Cerium gives rise to a blue fluorescence, vanadium oxide to a

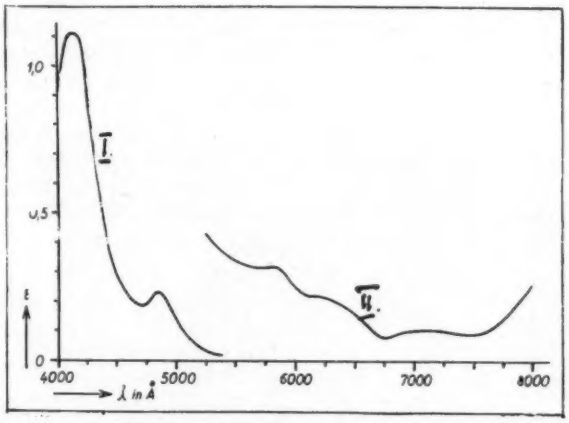


Fig. 19. Absorption spectrum of a uranium glass. (Curve II corresponds to the 10 fold thickness.)

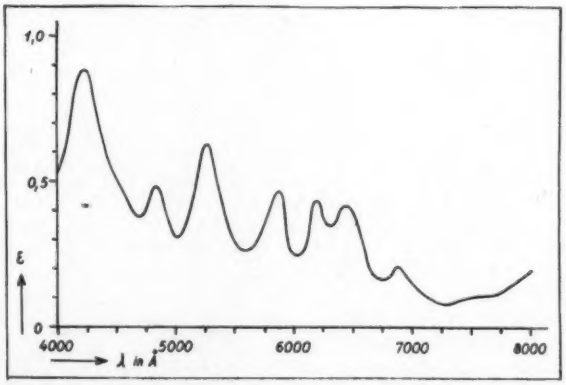


Fig. 20. Absorption spectrum of a potassium-uranium glass, molten under reducing conditions.

brownish green, manganese oxide to a green, samarium to a rose, and neodymium to a red fluorescence.

In general, the light energy which is absorbed by a glass is completely dissipated into thermal energy. However, in some cases, it is possible that an atom or ion which has absorbed light may drop down to a less excited level, thereby emitting part of the energy as light of a longer wave length. This is just the phenomenon of fluorescence. In order to obtain this, it appears essential that the excited ion shall be only slightly perturbed by the surrounding solvent molecules. In an aqueous solution, the strong perturbing action of the water molecules prevents the fluorescence of hydrated ions. As is indicated by the shift of the absorption bands toward the red, ions in glasses are not so strongly solvated as in aqueous solutions. This explains the fact that many ions in glasses show fluorescence, whereas their aqueous solutions never do.

Copper glasses—Copper compounds introduced into a glass give rise to a bluish or greenish color, depending upon the degree of solvation. Just as for nickel and cobalt glasses this solvation changes with temperature. It is therefore seen why blue copper glasses change to green with increasing temperature.

In addition to this dissociation-association process, a change in the state of oxidation of copper is possible. Under reducing conditions the blue color of the cupric silicates gradually disappears due to the formation of the colorless cuprous compounds. It is a characteristic property of these glasses that cuprous silicates can be stabilized by rapid chilling. However, if glasses containing cuprous copper are tempered in the softening range, the cuprous ions undergo an internal oxidation-reduction, forming cupric ions and metallic copper. Metallic copper in colloidal suspension gives rise to the well known copper ruby, and in high concentrations to the copper aventurine. (*To be concluded in May.*)

SAINT PAT GOES TO ALFRED

The birthday of St. Patrick, who has been adopted as the patron saint of ceramic engineers because he taught the Irishmen how to lay brick, was duly celebrated at the New York State College of Ceramics after the manner which has been followed for the past four years.

The good Saint, whose voice sounded very much like that of Jack Merriam, one of the seniors, appeared at the Assembly on the morning of March 17th, and reviewed the achievements of his protégés at Alfred for the past year, with special reference to the idiosyncrasies and shortcomings of the faculty. In a ceremony in which the blarney stone and the shillalah figured prominently, the members of the senior class in Ceramics and Glass Technology were made Knights of St. Pat. This illustrious order (Erin Go Bragh!) was also conferred upon S. F. Walton, of the Exolon Company, and on H. B. Du Bois of Consolidated Feldspar. Also knighted were H. G. Schurecht, head of the Engineering Experiment Station at Alfred, and John G. McMahon, his First Assistant.

The evening was given to the Annual Open-House Celebration in which the various departments and laboratories of the college were thrown open to visitors. About 700 persons attended and viewed the various experimental processes in operation, motion-picture films loaned by the Whitall-Tatum Company, and a demonstration of off-hand glass blowing by workmen from the Steuben Division of Corning Glass Works. Social events included a Tea Dance on Thursday afternoon, and a Grand Ball on Friday evening at which St. Pat himself and his Queen, selected by student vote from amongst the campus beauties, led the Grand March.

LOS ANGELES GLASS PLANTS VERY ACTIVE

• The Latchford Glass Co. is working on a modernization program and has a crew of erectors putting up new buildings and installing a 350 horsepower air compressor. The company reports that by redesigning and by the use of stackers, they have greatly increased their warehousing efficiency. They have also increased their tonnage capacity and are now preparing to operate a sixth machine, which is at present being installed.

• The Maywood Glass Co. is building another two machine melting unit that will double their capacity. They have also just completed the erection of a new warehouse.

• The Owens-Illinois Pacific Coast Co. has built a new office building of glass brick at their Soto St. plant. They have also completed a new melting unit and the building that houses it. In the lot north of the main plant, they are putting up a two story factory building said to be for the decorating department.

• Glass Containers, Inc., recently put in operation a new four machine tank and have new buildings to house all equipment necessary for this amount of melting capacity.

• At the Technical Glass Co. the capacity of two of the continuous tanks has been increased and a large number of illuminating glassware items have been added to their line. Due to the improvement in the building industry, their building glassware business has increased, and the plant is operating at capacity.

• Crystalite Products Corporation, Glendale, has added pole line insulators as well as a number of lighting units to their general line. This has necessitated another continuous tank and a six-foot automatic lehr.

• Having outgrown its old quarters, the Ralph Brown Mold Shop has purchased property at 1737 Standard Ave., Glendale, Calif. In addition to mold making, they have added such glass factory equipment as presses, cracking off machines, grinders and small tools.

AMERICAN CERAMICS EXHIBITED IN EUROPE

For the first time in history an exhibition of contemporary American ceramics is being sent to Europe upon official invitation from a foreign museum. The Syracuse, N. Y., Museum of Fine Arts has arranged and assembled such an exhibition which is being sent abroad to the Kunstindustri (Arts and Crafts) Museum in Copenhagen, Denmark. The exposition, sponsored by the American Ceramic Society, will then be shown at the Arts and Crafts Museum in Gothenburg, Sweden; the Swedish National Museum in Stockholm; Helsingfors, Finland, and the famous Hanley Museum in Stoke-on-Trent, England.

STEPPING UP PRODUCTION WITH FEEDER TEMPERATURE CONTROL

By O. P. KOSSATZ

The Brown Instrument Company

A number of years ago, forehearths consisted principally of short ports built into the refining end of a glass tank to guide the molten glass to a point where the gobs or mold charges could be conveniently placed in the forming or bottle machines. Such hearths or feeders were equipped with various crude heating or cooling devices to hold the temperature as nearly constant as possible. Due to lack of control of the variable factors, it was largely a matter of "take what you get." Enterprising organizations recognized the limitations of these old methods and, after years of constant development and concentration, feeders that assure great flexibility over a wide range of weights are now available and give the machine operators much better control over the many variable factors.

Some of these improvements consist of lengthening the feeder channels to allow more time for conditioning the glass by heating or cooling; the addition of mixing devices at the spout to insure an intimate mixture of

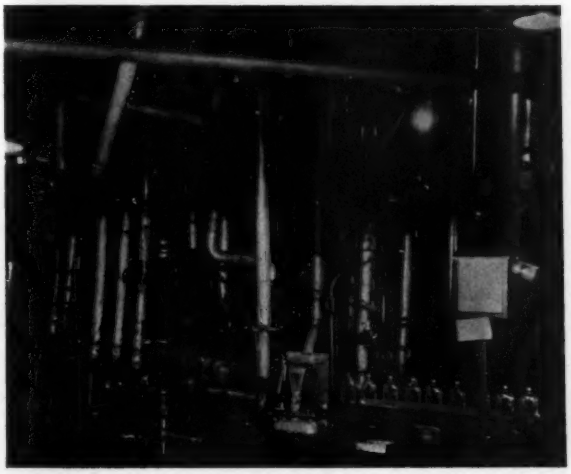


Fig. 1. A typical bottle machine.

the glass; burners on either side of the channel to heat the glass and the channel refractories, together with improved insulation, cause the glass to flow evenly throughout the entire cross section rather than in a narrow hot ribbon as before. These and numerous other improvements have been made with but one object—more bottles—greater production.

It has long been recognized that a further logical step in this direction would be in automatic control of the heat input to the feeder spout, since it is at this point that the glass is finally conditioned and the gob is formed. Automatic temperature control through the regulation of the spout burners should thus assist in securing a gob of uniform viscosity at all times, which in turn would insure production within the desired weight limits; thus eliminating the frequent necessary feeder adjustments for weight correction.

It was realized that numerous difficulties had to be overcome to accomplish this object since the resultant gob would be affected by a number of variable factors other than changes in B.t.u. value and pressure of the fuel. Some of these variables are:

1. Changes in temperature.
2. Changes in level of the molten glass in the nose or refining end of the tank.
3. The loss of heat of the surface glass from radiation.
4. The loss of heat from conduction through the eroding refractories.
5. Variations caused by manual adjustment of heating and cooling devices on the back end of the feeder.

The methods adopted to meet these problems are of general interest, especially since they have resulted in the final development of a successful simple system of glass feeder control.

In any control problem, the first thing to be settled is always the means of measuring the variable to be controled. This involves the selection of the best location for the thermocouple; a thermocouple being necessary, since radiation or optical devices would give surface temperatures only and not the true temperatures of

Fig. 2. Instrument cabinet for spout controller and channel recorder. Note location next to tank where operators can utilize equipment to greatest advantage.

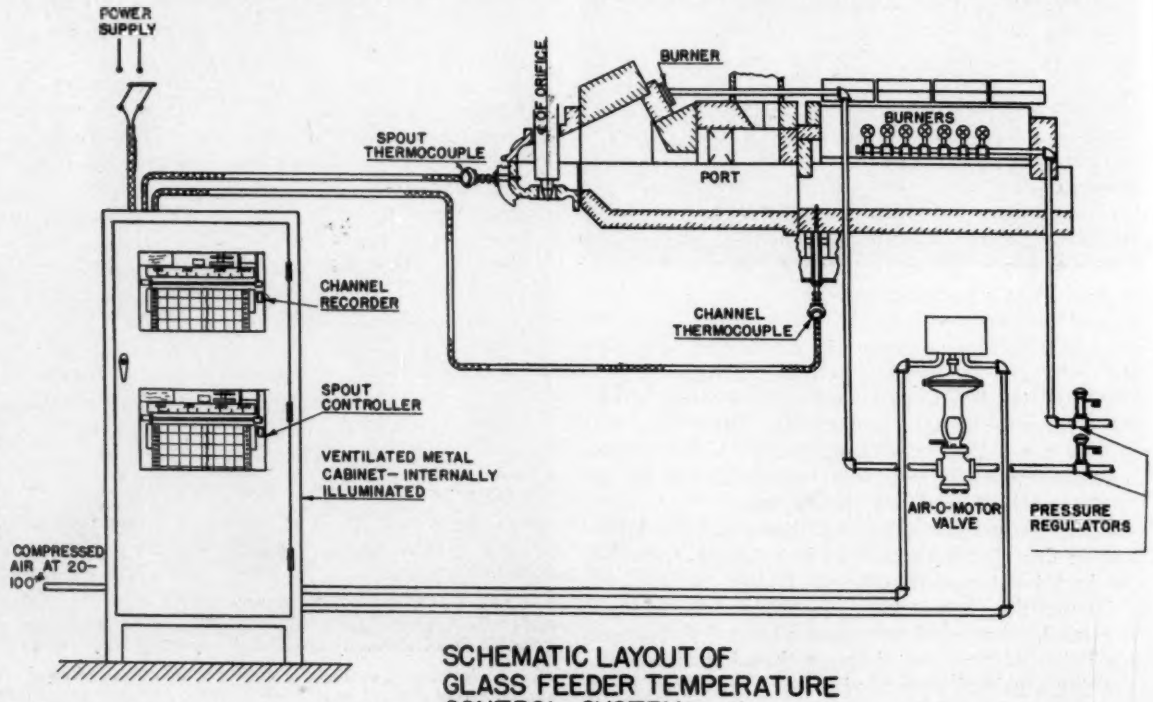
the entire mass of glass in the spout. Platinum rhodium thermocouples enclosed in Sillimanite protecting tubes placed just above the glass line and protected from flame impingement by a refractory housing were first tried, but discarded because of the great time lag between the temperature as shown by the thermocouple and the actual glass temperatures.

It was then decided that a thermocouple immersed directly in the glass without protecting tubes might give a temperature curve which would closely parallel the temperature curve of the gob. It was realized, of course, that this would increase maintenance cost, since the end of a standard bare thermocouple (.020″ wire) would invariably be ruined when spouts were replaced. Thermocouples were placed in a number of different points under the glass line to determine the best location to give the desired results. Those which were immersed vertically downward were unsatisfactory because of the fluxing action of the surface glass on the porcelain insulators, the difficulty of mounting, and because they would be in the way and subject to damage. The work eventually proved that the best, most significant, and most accessible spot in the feeder was about one inch below the minimum glass line and at a horizontal angle about 30° from the longitudinal axis of the feeder.

It was found that the temperature at this thermocouple location closely followed the temperature of the gob. To prevent bending and mechanical breakage, the bare thermocouple tip was made to extend into the glass not more than one-half inch. Suitable insulators to separate the wires and tubes to prevent insulating material from entering the glass were provided. The thermocouple construction has now been improved, and heavier platinum rhodium wires (.045″) are used which can generally be removed and replaced without damage.

The next step was to apply a controller for the fuel line. Of the several controller types available, the simpler varieties such as electric two and three position types were considered unsuitable because of the process time lag. A two-motor electric control valve capable of an infinite number of positions was selected and tried in combination with a recording control pyrometer. A control record with a slow drift of five degrees plus or minus was secured, which at that time (eight or nine years ago) was considered excellent; but the cost of the equipment required was considered excessive and further experiments were made. The next method of attack was through the use of a fast operating metal expansion type valve, in which current applied to heating coils around expanding metal rods in the valve caused a proportional increase or decrease in fuel flow. The valve was placed in an especially designed circuit which improved the control to approximately three degrees plus or minus (slow drift). There were still some disadvantages, however, among them being the necessity for the machine operator to reset the fuel supply to come within the range of the control valve, which required some knowledge of pyrometry on the part of the operator. In view of this necessary human variable, the system was discarded, and the next set of tests utilized the new Air-o-Line type of potentiometric control which overcame this disadvantage through its full throttling range action and its automatic reset feature which was not available in electric control.

This instrument utilizes compressed air, the pressure of which is regulated by the controller to correct deviations of the temperature from the desired control point. A secondary control function modifies this pressure dependent upon the time of deviation, and thus eliminates drifting from the control point. The regulated air pressure is applied to a spring loaded diaphragm of a valve in the fuel supply line through a positive valve posi-

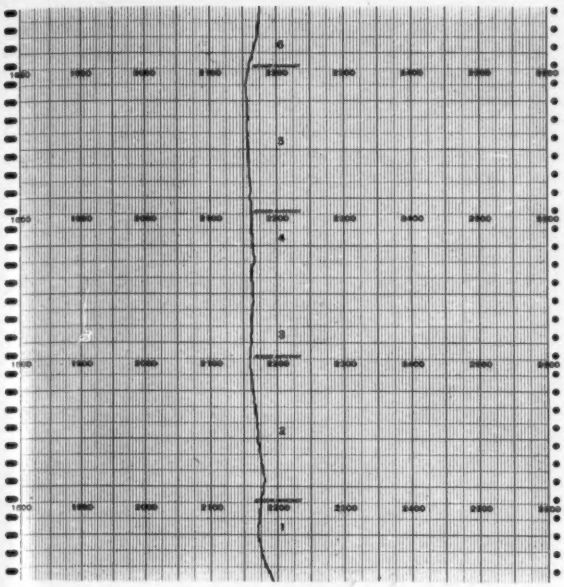


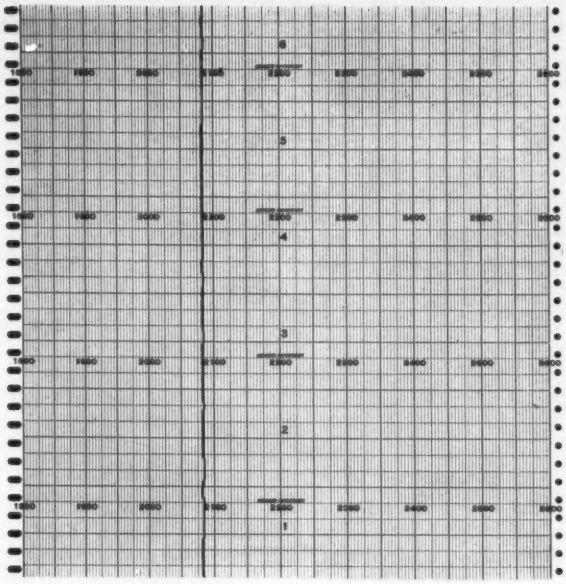
SCHEMATIC LAYOUT OF GLASS FEEDER TEMPERATURE CONTROL SYSTEM

Fig. 3

Fig. 4. Below. Record of spout temperature in forehearth under hand control.

Fig. 5. Right. Record of spout temperature in forehearth under Air-o-Lite temperature control.





tioner or relay which steps up the resulting controlled pressure to eliminate any valve friction, etc. The pressure is transmitted directly to the valve disc or plug which changes the fuel flow in direct proportion to the lineal valve lift. The Air-o-Line control system can hold the temperature of the glass in the spout within one degree plus or minus without cycling and without drift, and eliminates the necessity for adjustments either to the fuel or to the reciprocating plunger to change the weight throughout the entire run. The only requirement on the part of the operator is to reset the temperature control index on the outside of the instrument, if necessary, when a new job is started.

Additional experiments have been made to determine if there is any advantage in controlling the back burners on the channel from the temperature of a thermocouple located in the bottom of the channel. There appears to be no appreciable advantage in such control since the temperature control at the spout is fully capable of maintaining the temperature evenly though channel temperatures vary considerably. There is a definite advantage, however, in recording these channel temperatures on a standard recording pyrometer to guide the operators in duplicating conditions previously shown as ideal, such as setting dampers and back burners to prevent deformation of the gob. Furthermore, an additional saving in cost is possible by using a two record recording pyrometer wherein a single instrument records in different colors the channel temperatures of two feeders. The results obtained by the installation of this feeder control and recording equipment can be classified under three headings:

1. *Increased Production.*

(a) It increases packable ware through the indirect control of the weight of the gob or mold charge which assures the production of bottles of correct capacity.

(b) It minimizes stratification which results in strains.

(c) It reduces cullet.

(d) It permits setting the feeder to the proper conditions as noted on records made for previous runs of the same job. This results in the saving of time since the feeder will be operating correctly for the job by the time the machine is set up.

(e) It reduces shut down time due to inefficient operators and human errors.

2. *Greater Economy.*

(a) The low first cost of recording control equipment and low upkeep costs have been considered as major factors in designing and applying the equipment.

(b) It saves fuel because just enough heat is added to maintain temperature, and it saves wind by preventing the need for cooling normally required after a period of excessive heating.

(c) The perfection of the spout control eliminates the necessity of automatic control on the back burners of the feeder, although a record or knowledge of channel glass temperatures is a desirable adjunct to the spout control.

(d) It increases the life of refractories by preventing over-heating and preventing excessive expansion and contraction because it maintains constant temperatures.

(e) It results in smoother operation.

3. *Increased Quality.*

(a) It assists in maintaining more accurate capacities.

(b) It reduces improper annealing due to stratification.

(c) It increases uniformity of the product because it eliminates the human element.

In constructing a new research laboratory at Middletown, Ohio, the American Rolling Mill Co., is utilizing porcelain enameled sheet steel and glass both in the form of plate and blocks. Stainless steel bands will run all around the building to add to its modern appearance. Charles R. Hook, president of the company says, "This building will demonstrate the full force which low-priced sheet and strip steel can exert in reviving construction."

SIMPLE TESTS OF GLASSES AS TO THEIR STABILITY AGAINST ATMOSPHERIC ATTACK

In the *Glashütte* for February 20, 1937, Fritz Stein reports on a number of methods used for making rapid and simple tests of weathering. These tests have been collected at the suggestion of Professor Springer and will be further elaborated in the School for the Glass Industry in Zwiesel. It is remarked that the attack upon glass by weathering can be tested by very definite processes. Most of these are too elaborate for the ordinary establishment, therefore certain tests are being reviewed which will simulate natural conditions and which because of their simplicity can be carried out at small expense and in a very brief time which makes them more suitable for small factories.

It is evident that the direct attack of water upon glass is not quite the same as that of atmosphere. Whereas water forms principally a sodium hydroxide solution on the surface, when the atmosphere is concerned, there is also, because of the presence of carbon dioxide, a solution of sodium carbonate formed which brings about a somewhat different effect upon the surface. This fact alone makes it obvious that testing glasses with water does not yield a precise estimate of the weathering effect, especially since tests are usually made in hot water and with the glass in powdered condition.

Weberbauer has come to the conclusion, after thorough experimentation, that weathering goes more like the attack of hot acid rather than that of hot water. If it is desired therefore to determine the conduct of the glass toward the atmosphere, one might well make use, with some caution, of the acid testing.

1. The Hydrochloric Acid Test According to R. Weber

The old hydrochloric acid test proposed by Weber in 1863 is due for consideration. This process is applied to the rapid testing of all glasses, especially the usual hollow ware, plate and mirror glass, and is certainly applicable if not quite sufficient. The piece of ware concerned is well cleaned with water and alcohol and exposed to the vapor of hydrochloric acid for 24 hours or longer. The piece is then dried in a room free from dust or fumes of ammonia or, for exact work, over quick lime. According to this test, defective glasses will show a strong milky coating of alkali chlorides; better glasses show only a slight strain or weak irridescence; good glasses must be completely unattacked and lustrous. The pieces are best viewed in reflected light except broken fragments, which may be held parallel to a window and viewed at an angle of 30-40°. Thus the most delicate surface effect may be recognized and compared as to strength. To be sure, this test requires experience. Unpolished pieces can very obviously not be used.

2. A Hydrochloric Acid Surface Test

According to the results of the work of Weberbauer, useful information can be obtained from the following test procedure. It is easily carried out because of its simplicity. The glass objects to be tested are placed in a container which will not be attacked by the acid, and covered completely with 10 per cent hydrochloric acid. This bath is then warmed to 40-50°C and held at this temperature about three hours or longer. Then the glass is dried in a room which is free from any gases or vapors which may attack it. Any evident, more or less strong attack of the glass, is recognized by a surface change. For comparison purposes, a control piece of glass that has a recognized resistance to chemical attack is put through the same test. This process would be the first one investigated at Zwiesel.

3. The Carbonic Acid Test of Spate

Späte made use of a carbon dioxide atmosphere saturated with water vapor at room temperature, which corresponds to an exaggerated reproduction of the attack of the atmosphere on the glass. The clean ware is placed in a flask with a little water and then carbon dioxide is introduced until a slight pressure is developed. The ware remains closed up in this receptacle for four to ten days and is then dried in a similar flask in which sulphuric acid or calcium chloride is used as a drying agent. The character and degree of precipitated film produced is a measure of the attackability. In order to study the condition of the glass surface after the operation, it is cleaned carefully with hydrochloric acid and again dried. Glasses which have little chemical resistance show marked attack on the surface which will be slightly etched, or often iridescent. The glasses can be divided into four groups: (1) Traces of precipitate; after cleaning, a blank surface; (2) limited but evident precipitate; after cleaning, a blank surface; (3) heavy precipitate; a blank surface after cleaning; (4) heavy precipitate; small flecks on the surface after cleaning.

4. The Tropical Room Test

Here the weather conditions in the tropics are imitated on a small scale. This method was developed by Dr. C. Reiter, of the Osram Company. In this room, a temperature of 38°C is maintained during the day, and 40° in a saturated atmosphere during the night. Thirty-eight degrees Centigrade corresponds to the dew-point in the tropics. The glasses to be tested are kept from two to four months in this sort of atmosphere. After this time, they are washed with boiling water and graded according to the following five degrees of weathering: (1) Completely unattacked; (2) Very slightly attacked; (3) Slightly weathered; (4) Strongly attacked; (5) Very strongly attacked.

5. The Narcotin Test

In addition to these easily conducted acid tests, there remains to be considered the use of the Narcotin test which offers very good prospects as a standard test procedure for pharmaceutical ware. This may be good enough also to apply to other varieties of glassware, since it makes use of cold water conditions quite comparable to the natural weathering.

Announcement has been made of the appointment of J. Scott Walker as sales manager of the Fourco Glass Co. Mr. Walker's headquarters will be in the Union National Bank Building, Clarksburg, W. Va.

PHYSICAL METHODS FOR CONTROL WORK

Nearly all glass troubles arise from the fact that most of the important physical properties of glass vary with changes in the composition of the glass. For example, troubles such as cordy glass, devitrification, variable working qualities, welding and flashing difficulties and the like can usually be traced back to unintentional changes in the glass composition. The determination of certain of the physical properties of the glass, either by routine control methods or when trouble is being experienced, therefore, offers an excellent means of minimizing such troubles, as a radical change in a physical characteristic of the glass indicates a change in the glass composition and often points to the cause of the trouble.

For quick checking or routine control work the glass technologist must have methods that are quick and simple to perform and equipment that is not excessively expensive and which is fool-proof. Both the methods and equipment must also possess a fairly high degree of accuracy if correct interpretations are to be made from the results obtained. The following methods, descriptions of which have appeared in glass literature at various times, have been selected as being excellent for meeting the needs of the problems encountered in the plant laboratory.

Very often it is necessary to determine the difference in expansivity of different glasses. For example, in the case of flashed or welded glasses it is important that the expansivities of the two glasses be nearly equal if breakage of the flashed or welded piece is to be prevented. In the case of cordy glass where the cord is causing a casing effect it is sometimes possible to separate the cord from the normal glass and by comparing their expansions to determine the cause of the cord.

While the coefficient of expansion of a glass may be accurately determined by interferometric methods, such equipment is not available to the usual glass plant laboratory. Sharp[1] has outlined a test which, in addition to being both speedy and simple to perform, also requires very little equipment. This method known as the "welding test" is as follows: two rods of glass, one of which is the test piece, are worked in the flame of a blast lamp until the ends of the rods become soft. They are then held together along side of one another so that the softened ends weld together into a single rod (Fig. 1a). The junction so formed is then carefully heated and shaped with a pair of forceps into a form which may easily be drawn out. The end of the junction is then grasped with the forceps and the junction heated in the blast until it is uniformly hot for about ½ inch of length. During the heating period it is important that the softened junction does not become twisted. When the junction becomes soft enough the flame is removed and the softened junction quickly pulled out into the form of a thread about 10 inches long. The tension is maintained until the softened glass "sets" (Fig. 1b). The glass held in the forceps is then broken away from the thread and the thread held in a vertical position for examination.

A glass thread formed in the above manner consists of two kinds of glass, one on one side and one on the other side. If then, there is any difference in the expansivity of the two glasses forming the thread, a greater contraction will occur on one side of the strip than on the other and the strip will bend into the shape of a curve instead of hanging vertically. The glass having the higher co-efficient of expansion will be on the inside of the curve. If the difference in the expansivities of the two glasses is very great the thread will wind up into spirals when the tension is released. With small differences in expansions, only a slight curvature of the thread will be noticed. The test is extremely delicate and is accurate to about two units in the seventh decimal place.

Not only can the difference in the expansion coefficients of different glasses be determined by the "welding test" but the actual coefficient of expansion of an unknown glass can be determined with a very good degree of accuracy through the use of standard rods of glass having known coefficients of expansion. The standard rods should range in value from 0.0000025 to 0.000015 by steps of about 5 in the seventh decimal place.

When the coefficient of expansion of an unknown glass is to be determined, a standard glass is selected having an expansion coefficient midway between the two limits and the unknown glass welded to this sample. An examination of the thread will quickly show whether the standard has an expansion above or below that of the unknown. A standard glass midway between the limit and the glass first used is then selected and the "welding test" repeated. This procedure is followed until a standard glass is found that matches the unknown sample.

In the welding tests and in many other tests it is necessary to have the sample in the form of a rod. The formation of a passable rod from an irregularly shaped piece of glass is a simple procedure and requires little knowledge of the lamp-working art. A sharp corner of the sample is heated in the flame along with the end of a rod made from a glass having a high softening point. When both are soft, seal the sample to the end of the rod and remove from the flame. When "set," heat an opposite corner of the sample and the end of another rod. The entire piece of glass is then placed in the flame and heated as uniformly as possible. As it softens twist the rods while exerting a slight endwise compression. The sample will form into a helix and finally take the shape of a ball. Continued heating and working in the flame will smooth out the surface wrinkles. While the ball is hot it is removed from the flame and slowly drawn out into the shape of a rod.

The determination of the specific gravity is an ex-

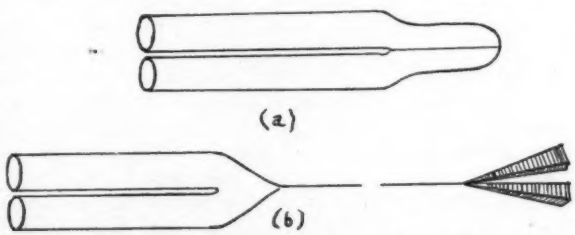


Fig. 1. The "Welding Test" suggested by Sharp.

[1] J. Am. Ceram. Soc. 4, 219-33, 1921.

tremely simple and rapid method for distinguishing between different glass as the procedure is not difficult and special apparatus is not required. A very quick determination of the specific gravity of a glass sample may be made by the flotation method. A heavy liquid such as bromoform (bromoform has a specific gravity of about 2.88) is used and the glass sample dropped into it. The size of the sample has no influence on the test and may be as small as BB shot. A lighter liquid such as acetone or carbon tetrachloride is then added in small amounts, followed by a thorough shaking of the mixture. The addition of the lighter liquid is continued until a dilution is reached in which the glass sample will neither sink nor float but seems to remain suspended in the liquid. The specific gravity of the glass sample is then the same as that of the liquid mixture. The gravity of the latter is then determined with a Westphal balance or by other means.

The flotation method offers a quick means of differentiating between different glasses; for example, if several different glass compositions are being used and doubt arises as to the composition of the glass comprising a certain article a comparison of the gravity of the glass in question with standard samples of the different glasses may be made in a few minutes by the flotation method. It is also a useful tool in tracking down cordy glass causes especially in cases when the cord is such that a casing of appreciable depth is produced. By separating the casing from the body of glass by cutting or grinding, a comparison of the density of the casing and cord free glass may be obtained. Such a comparison often offers a clue to the cause of the cord.

The flotation method finds its chief sphere of usefulness where quick determinations of specific gravity are required but can be adapted to routine control if precautions are taken to insure that all determinations are made at the same temperature. For control work the specific gravity is usually determined by the loss in weight method as the equipment required (namely, a chemical valance, a beaker, thermometer, distilled water, and a fine wire or silk thread) is found in every laboratory.

The loss in weight method is well known and consists of first weighing the glass in air followed by a weighing in distilled water and the loss in weight obtained by the difference in weighings. If silk thread is used for suspending the sample in the water its weight is usually negligible and may be disregarded. If a wire is used for this purpose it must be weighed alone while suspended in the water and the results corrected for its presence. The loss in weight in water is then divided into the weight of the sample in air to obtain the specific gravity. For accurate work the water used should be free of dissolved gases, the glass free of blisters, seeds, stones and other foreign material, and the results corrected for the change in density of the water with temperature. Table I gives the correction factors that must be used for various water temperatures.

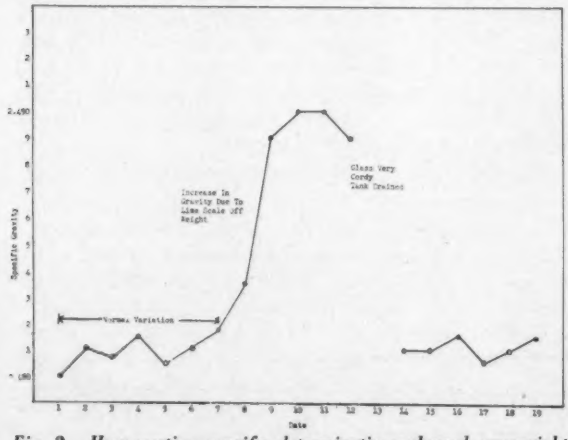


Fig. 2. How routine specific determinations showed overweight lime scale.

TABLE I. SPECIFIC GRAVITY CORRECTIONS

Water Temp. °C	Correction	Water Temp. °C	Correction
10	0.00027	22	0.00220
11	0.00037	23	0.00243
12	0.00048	24	0.00267
13	0.00060	25	0.00292
14	0.00073	26	0.00318
15	0.00087	27	0.00345
16	0.00103	28	0.00373
17	0.00120	29	0.00402
18	0.00138	30	0.00432
19	0.00158	31	0.00463
20	0.00177	32	0.00494
21	0.00198	33	0.00527

The routine determination and plotting of the specific gravity of the glass being manufactured from day to day will quickly show up composition changes and will in many cases predict cordy glass troubles before they occur. Fig. 2 shows how routine specific gravity determinations picked up an over-weight lime scale. When radical changes in the specific gravity of the glass are noted it is well to make a check up on the batch materials, the batch, tank temperatures and tank pull and other variables that are responsible for cordy glass and hence variable specific gravities.

Another excellent routine control test for composition changes is the softening point test originated by Littleton[2]. The equipment required consists of a specially designed furnace[3] consisting of a cast iron core with a small hole running through its axis. A hole is also provided for a thermocouple for the measurement of the furnace temperature. The core is insulated with mica and wound with nichrome resistance wire or ribbon. The furnace is surrounded by a metal shell with a transite top and bottom, the space between the shell and core being filled with Sil-o-cel powder. A mirror and scale are used for reading the position of the end of the test piece. (Fig. 3).

The procedure used is as follows: the glass to be tested is first worked into the shape of a rod and then drawn out into a thread of about one millimeter in diameter. After the thread becomes hard its diameter is measured at various points along its length with a micrometer. A section about 10 inches long and having very nearly the same cross-sectional area throughout is cut from the thread and used as the test piece. One end of this thread is heated in the flame so as to form a ball of glass about 1/8 inch in diameter. At a point about 9 inches below the ball a needle point about one millimeter long and bent at right angles to the length is formed.

The specimen is then suspended in the furnace, pointed end down, so that the pointer points to the scale. The

[2] J. Am. Ceram. Soc. 10, 259-64, 1927.
[3] The complete assembly is now being supplied by Bailey and Sharp Co., Hamburg, N. Y.

furnace is then leveled so that the thread hangs directly down the center of the tube and does not touch the side of the furnace. At the start of the test the furnace temperature should be about 50 to 100°C below the softening point of the glass being tested. The furnace temperature is then raised uniformly at a rate of about 5°C per minute. The position of the glass pointer on the millimeter scale and the furnace temperature is then taken at intervals of one minute. By plotting the elongation against time and drawing a tangent having a slope of one millimeter per minute to this curve the point at which the elongation is proceeding at the rate of one millimeter per minute is determined. This point is termed the softening point, as defined by Littleton.

Not only can the softening point method be used in control work as a daily check on glass composition variations but it is also useful for investigating the effect of composition changes on the viscosity of glass in this low temperature range. It may also be used for comparing the workability of one glass with another and as a means of differentiating between glasses similar in other physical properties but differing in their softening point.

Refractive index is another physical property of glass that can be used for detecting composition changes or differences in composition. If a microscope is available this property can be quickly determined on very small chips of glass by any of the usual immersion methods. One such method which is used quite extensively is the central illumination or Becke method. The procedure is as follows: The glass is crushed and some of the grains

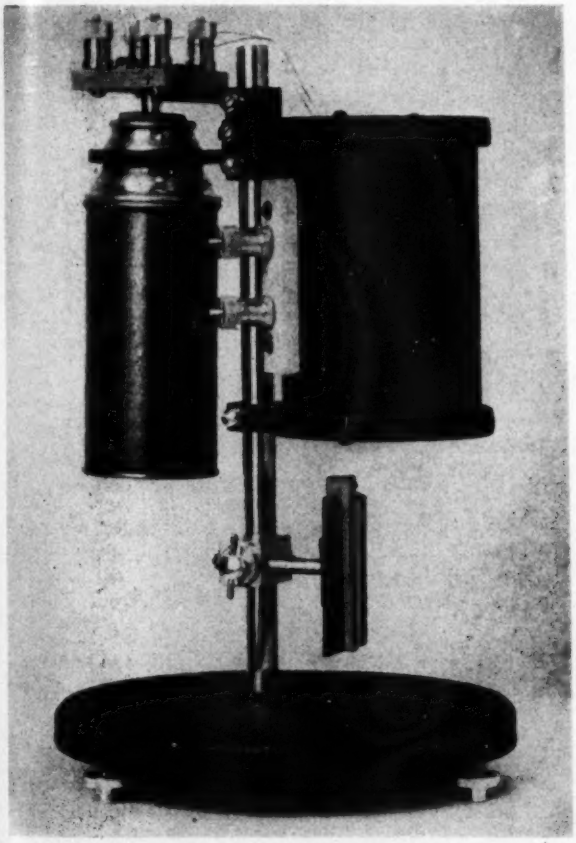


Fig. 3. Routine control testing equipment.

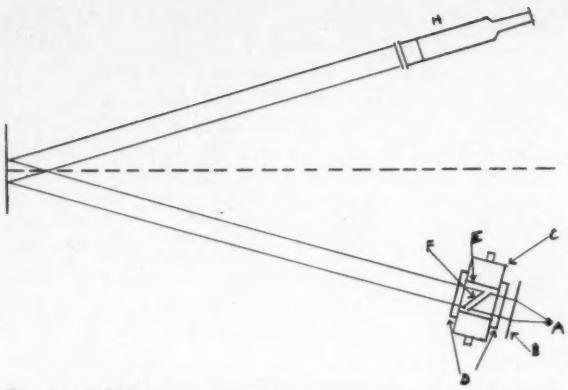


Fig. 4. A, light source. B, object screen. C, water jacket. D, glass windows. E, immersion cell. F, glass sample. G, mirror. H, telescope.

placed on the microscope slide and covered with a liquid of known refractive index. The substage diaphragm of the microscope is then almost completely closed. On observing the field under these conditions a bright line will mark the border of each grain of glass. This bright line moves out into the liquid or in toward the center of the glass grain as the tube of the microscope is lowered from the position of good focus. This bright line is known as the "Becke line" and will move out toward the liquid as the tube is lowered if the grain has a higher index than the liquid. When the index of the liquid is close to that of the glass grains, the grains tend to disappear and the Becke line is no longer a white line but is a band of colored lines. If the liquid and grains do not match, other liquids are tried until a suitable match is obtained. Liquids that are suitable for immersion media may be purchased from dealers in the form of sets but if an Abbe refractometer is available they may be made up from the end members of the liquids given in Table II.

TABLE II. REFRACTIVE INDEX LIQUIDS

Material	ND
Iso-amyl-iso-valcrate	1.41
Light mineral oil	1.46-1.47
Halowax oil	1.63
Alpha monohromnapthalene	1.66
Methylene iodide	1.74

By the use of an Abbe refractometer the refractive index of larger samples of glass may be determined. With this instrument it is necessary for the glass samples to be homogeneous, well polished on one flat surface and to have one end polished so that a sharp edge is formed at right angles to the flat surface. The sample is then placed on the instrument and the refractive index read directly from the scale after the field is matched.

When polishing equipment is not available the measurement of refractive index may be made by the immersion method as used by Faick and Finn[4]. The apparatus required is shown diagrammatically in Fig. 4 and consists of an immersion tank equipped with a water chamber through which a constant temperature water supply is circulated, thereby eliminating errors due to temperature variations; an object screen made from a piece of fine ground glass on which black cross-lines are ruled; a sodium flame light source; an observation telescope; a

[4] J. Am. Ceram. Soc 14, 7, 518, 1931.

mirror; a clip for suspending the glass sample in the immersion tank; and a stirrer for mixing the component oil.

In determining the index of refraction of the sample, the object screen is illuminated by the sodium flame, the light after passing through the oil and the glass sample being reflected by the mirror to the telescope which is focussed on the lines of the object screen. The glass sample is then rotated while viewing the lines on the object screen. If the immersion liquid and the glass sample match, no distortion or shifting of the lines is observed. If a match has not been reached, small amounts of one or the other oils are added with constant stirring until the proper match is obtained. A sample of the oil is then taken and its index of refraction measured with the Abbe refractometer. Halowax oil and light mineral oil are satisfactory for use as immersion liquids in this method.

An important point to bear in mind when using any of the above methods is that it is often possible for the composition of the glass to change in such a manner that the physical property being measured is not changed. Although such a condition is fairly rare, it is always well to measure several different physical characteristics when composition changes of the glass are suspected.

WPA ERECTS GLASS BRICK STRUCTURE

On the site once occupied by the palatial Vanderbilt mansion at New Dorp, Staten Island, N. Y., Works Progress Administration engineers are erecting an $18,000 glass brick machine shop and instrument room as a facility of the Miller Aviation Field. The estate was purchased by the Federal Government in 1918 and converted into an aviation field for the 17th Division of the New York National Guard. The foundation has already been laid for the new glass house which will measure 100 by 20 feet, and will be located on the east side of the plane hangar. Built of glass bricks, the building will be without windows, but the interior is assured of ample daylight.

The glass bricks are blocks as long as an ordinary brick, but twice as wide and at least one-third thicker. By a special process of enameling and sanding, the sides of the block are prepared to cement against mortar. A single block withstands a pressure of 72,500 pounds. The block also reduces heat flow, deadens sound, resists fire and deflects sun glare, as well as transmitting and diffusing light.

Condensation on inside walls has been practically eliminated by the glass blocks. Tests have shown that there is no "sweating" of the walls when the outside temperature was 16 degrees below zero and the inside temperature 70 degrees, with 40 per cent relative humidity.

TO SEE EUROPEAN OPTICAL RESEARCH

American industrialists will have an opportunity to observe developments in European optical research this summer during a unique tour of scientific laboratories being arranged by the National Research Council's Division of Engineering and Industrial Research. About 100 prominent bankers and industrial men including leaders in the optical field are expected to participate in the tour which will enable them to visit world-famous laboratories where future European products are being developed. Of particular interest to optical men will be a visit to the Institut D'Optique in Paris. Other prominent laboratories included in the itinerary are the Cavendish laboratory in Cambridge, Metropolitan Vickers in Manchester, England, and the Siemens laboratories in Germany.

Research laboratories of 18 major fields of industry will be visited in England, France and Germany, besides those of trade associations, governments, and universities. In addition, accommodations will be made on the request of any member of the tour for special side trips to industrial laboratories not included in the general plans. Foreign hosts will be such organizations as the Department of Scientific and Industrial Research in England, the Verein Deutscher Ingenieure in Germany, the Sorbonne in France, and others.

The group will sail May 14 from New York on the S.S. *Champlain*, according to present plans. Travel arrangements are being made by American Express Co.

GERMAN CHEMICAL EXHIBITION

A profusely illustrated invitation to the Achema VIII Chemical Engineering Exhibition has just been published. This exhibition will be held July 2-11, 1937, at Frankfort-on-Main, on the occasion of the National Congress of German Chemists, the Semi-Centennial General Meeting of the Verein Deutscher Chemiker as also of other meetings of scientific and technical societies. The contents of this prospectus informs the reader about size, arrangement and other important details. The number of exhibitors already totals nearly 300. Interested firms and persons will receive the prospectus free of charge from the organizer and promoter of the ACHEMA, the DECHEMA, Deutsche Gesellschaft für chemisches Apparatewesen E. V., Potsdamerstrasse 103a, Berlin W. 35.

REVIEW

The Glass Industry in Italy (*L'Industria del Vetro in Italia*) by Prof. Corrago Rovini, University of Pisa.

This is an account some 25 pages long of the history of glassmaking with special references to Italian practice, and to a great extent with relatively modern developments. It is illustrated with 35 figures, some in the forms of diagram, some reproductions of prints and photographs. In the latter case they are not always particularly clear. The plate glass industry is not illustrated, but some considerable amount of space is given to the now extinct Lubbers (American Window Glass) still in the process of drawing sheet glass, and to processes of making bottles, tumblers, and so forth. The older methods of hand operation are discussed in some detail so far as the short space available permits. There are no outstanding novelties, but as an account of Italian practices and experience, the paper is useful. It was of course Italy that kept the glass industry alive between the time it collapsed in the Orient and the time it became developed in Western Europe.—F. W. P.

In a report to the Atlantic States Shippers Advisory Board, J. C. Magness, chairman of the glass container committee, estimated requirements for the first quarter of 1937 to be 2,275 cars. This is about an eight per cent increase over actual shipments of glass containers in the first quarter of 1936.

EQUIPMENT AND SUPPLIES

SIMPLEX CHANGES NAME

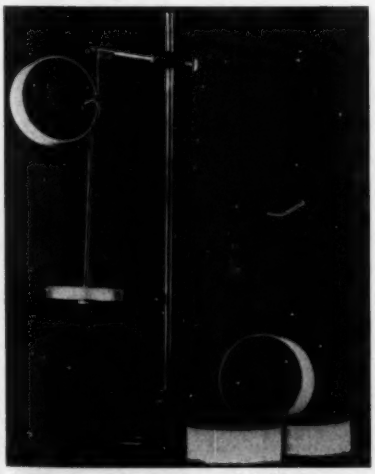
As a matter of corporate convenience the business of The Simplex Engineering Company in all states will hereafter be conducted under the name of Frazier-Simplex, Inc., without change in ownership or management. Practices, policies, and activities of The Simplex Engineering Company, developed during 19 years of business will continue unchanged.

XALOY CAN CUT GLASS

The Wilcox-Rich Division of the Eaton Manufacturing Co., Detroit, Mich., suggests that the application of an Xaloy lining or coating to bushings or rollers in equipment subject to abrasive wear will greatly cut down the expense of shutdowns and the frequency of replacements. Xaloy has a tensile strength of 43,000 pounds per square inch and a compression strength of 240,000 pounds per square inch. Its coefficient of thermal expansion is 7.2×10^{-6} per inch per degree F. and its thermal conductivity is 7.5 B.T.U.'s per hour per square foot per degree F. Its hardness is equivalent to 750 Brinell or 68 to 70 Rockwell C scale.

EXPAND-O-METER

One of the important physical properties which affects the usefulness of ceramic articles is the fit between glass and its decoration, glaze and the body, porcelain enamel and the base metal. Heretofore, it is said that the difficulty of determining the coefficient of expansion and the high temperature range necessary for these materials have retarded progress in this field. However, the O. Hommel Co., Pittsburgh, announces that it has developed an instrument which makes it a simple matter to determine the expansion of glasses between the softening point and the room temperature. The Rosenberg Expand-O-Meter is said to require a minimum of time to operate, and a test in the hands of a non-technical trained worker can be made in 30 minutes. This instrument and its method of operation were described by Rosenberg and Langerman in the Journal of the American Ceramic Society (19, 86-90, 1936).



• *The Rosenberg Expand-O-Meter*

CATALOGS RECEIVED

Gas Producer Regulator—Remote Controllers. Bulletin No. 33. Chowning Regulator Corporation, Corning, N. Y. Illustrated and described are a typical application of this equipment together with photographs and a diagram of the remote gas pressure regulator, controller and shut-off valve. A performance chart record is also shown.

Non-Indicating Temperature and Pressure Controllers. Catalog No. 900C. C. J. Tagliabue Mfg. Co., Park and Nostrand Avenues, Brooklyn, N. Y. A fully illustrated publication showing the applications of these controllers.

Brown Flow Meters. Catalog 2004. Brown Instrument Co., Philadelphia. A very handsome and colorful new 56 page book describing the company's electrical and mechanical flow meters. Included are descriptions of Air-O-Line flow and liquid level controllers with their applications.

Ful-Kontrol Laboratory Heater. Bulletin TS 1600. Precision Scientific Co., 1750 N. Springfield Ave., Chicago. A new laboratory heater which adjusts from 0 to 750 watts, for mild or intense heating. A built-in auto-transformer is used instead of a rheostat to reduce heat dissipation.

Pillow Blocks. Randall Graphite Products Corporation, 609 West Lake St., Chicago. The new 1937 catalog gives complete specifications and installation data on six types of pillow blocks, including a universal-position model.

Model 36-A Diesel Power Units. Bulletin 3600-A1. Fairbanks, Morse & Co., 900 South Wabash Ave., Chicago. Describes the construction and applications of Model 36, a medium high-speed, four-cycle Diesel. Offered in two cylinder sizes and in various combinations, with rating as low as 10 h.p.

Consolidated Odor Absorbers in Air Conditioning. Consolidated Air Conditioning Corp., 114 East 32nd St., New York. Covers the question of cost of operating an air conditioning system.

Bag Type Dust Arrester. Bulletin No. 163-1. Northern Blower Co., 6409 Barberton Ave., Cleveland. This arrester was developed primarily to meet the demands of those using Norblo continuous operating air filters. Fully illustrated, including diagrams and specifications.

Floor Trucks. Circular No. 225. Lewis-Shepard Co., 259 Walnut St., Boston, Mass. Included are lift trucks, skid platforms, stackers, portable elevators, portable cranes, special lifters, and steel storage racks.

Type "EQ" Low Lift Platform Trucks. Elwell-Parker Electric Co., Cleveland, Ohio. These machines have a capacity of 3,000 pounds and are said to be the smallest trucks capable of handling skids of the same size and capacity formerly used with hand lift trucks.

Multiple Groove Drives. No. 782. *Fractional Horsepower Single Groove Drives.* No. 783. Rockwood Manufacturing Co., Indianapolis, Ind. Two new data books presenting the purposes and prices of Rockwood V-Belt Drives.

An agreement for the acquisition of the complete line of pneumatic controls manufactured by the National Regulator Co., Chicago, has been entered into between that company and Minneapolis-Honeywell Regulator Co.

CO-ORDINATED RATE GUIDE

Just off the presses is the *Co-Ordinated Rate Guide* published by the Consolidated Guide Corporation, Chicago, for shippers everywhere in America. Almost instantaneous comparison of shipping charges is said to be possible. It presents in parallel columns the rates applying to rail, truck, express and parcel post shipments from hundreds of key cities to thousands of destinations all over the country. To further simplify rate finding, 12 pages of the index are devoted to an alphabetical list of railroad, navigation and motor carriers and 143 pages to an alphabetical list of cities, towns and villages served by these carriers. Where a hamlet has no rail connection the name of the nearest railroad receiving point is given. Practically all shipping information, including a supplemental binder for rate changes, is contained in this 1,350 page volume.

NEW SCREW TAKEUP

A new protected screw takeup for conveyors and elevators has been introduced by the Jeffrey Manufacturing Co., Columbus, Ohio. The adjusting screw is protected from dust and dirt by an inverted-U shaped shield which extends from end to end of the takeup frame. The sliding base casting is cored out in such a way that it slides freely over the shield, thus relieving the shield of any function other than protecting the screw. As the adjusting screw does not travel but remains inside the frame, it is protected from damage at all times. The screw is also protected from operating strains and shock for, after adjustment, the bearing is rigidly clamped to the rugged steel frame.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

Base Materials

		Carlots	Less Carlots
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	40.00	45.00
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Borax ($Na_2B_4O_7 10H_2O$)	lb.	....	....
Granulated	In bags, lb.	.020	.0245-.027
Powdered	In bags, lb.	.0225	.027-.0295
Boric acid (H_3BO_3) granulated	In bags, lb.	.0475	.0525-.055
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07⅛
Cryolite ($Na_3Al\ F_6$) Natural Greenland (Kryolith)	lb.	.08½	.09
Synthetic (Artificial)	lb.	.08½	.09
Feldspar—			
20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	31.50	....
In bags	ton	33.10	38.00-40.60
Kryolith (see Cryolite)			
Lead Oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.09¾	10¼
In 5 Ton lots	lb.	....	.09½
Less than 5 Tons	lb.	....	.10¼
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	....
Burnt (CaO) ground, in bulk	ton	7.00	....
Burnt, ground, in paper sacks	ton	9.00	....
Burnt, ground, in 280 lb. bbls.	Per bbl.	2.25	2.25
Calcined (K_2CO_3) 96-98%	lb.	.06¾	.07⅜
Hydrated 80-85%	lb.	.06	.06¼-.06⅜
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Soda ash (Na_2CO_3) dense, 58%—			
Bulk	Flat Per 100 lb.	.95	....
In barrels	Per 100 lb.	1.35	....
In bags	Per 100 lb.	1.10	....
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls.	Per 100 lb.	....	2.25-2.65
95% and 97%			
Bulk	Per 100 lb.	1.275	....
200 lb. bags		1.34	1.39
100 lb. bags		1.375	1.425

Special Materials

		Carlots	Less Carlots
Aluminum hydrate ($Al(OH)_3$)	lb.	....	.03½
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Antimony oxide (Sb_2O_3)	lb.	....	.16¾
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03	.03¾
Barium nitrate ($Ba(NO_3)_2$)	lb.	....	.07¾
Rutile (TiO_2) powdered, 95%	lb.	.10-.12	.13-.15
Sodium fluosilicate (Na_2SiF_6)	lb.	.06½	.07
Tin Oxide (SnO_2) in bbls.	lb.	....	.64
Zinc Oxide (ZnO)			
American process, Bags	lb.	.06	.06¼
White Seal, 150 lb. bbls.	lb.	.08	.08¼
Green Seal bags	lb.	.07½	.07¾
Domestic White Seal bags	lb.	.08	.08¼
Red Seal, bags	lb.	.07	.07¾
Zircon			
Granular (Milled .005-.02c higher)		.07	.07½-.08
Crude, Gran. (Milled .005-.02c higher)		.03½	.04-.05

Coloring Materials

		Carlots	Less Carlots
Barium selenite ($BaSeO_3$)	lb.	....	1.50-1.75
(Commercial, 25% Selenium)	lb.	....	.90
Cadmium sulphide (CdS)	lb.	....	.90-.95
Chromite	lb.	....	.0215
Cerium hydrate			
100 lb. drums and 600 lb. barrels	lb.	....	.60
Chrome Oxide Green, 400 lb. bbls.	lb.	....	.21-.26
Cobalt oxide (Co_2O_3)			
In bbls	lb.	....	1.41
In 10 lb. tins	lb.	....	1.51
Copper oxide			
Red (Cu_2O)	lb.	....	.22
Black (CuO)	lb.	....	.18¾
Black prepared	lb.	....	.22
Iron Oxide—			
Red (Fe_2O_3)	lb.	....	.0125
Black (Fe_3O_4)	lb.	.04½	....
Iron Chromate	lb.	....	.035-.05
Lead Chromate ($PbCrO_4$)	lb.	....	.16
Manganese, Black Oxide			
In Paper bags	ton	50.00	53.00-58.00
In Burlap bags	ton	52.00	55.00-60.00
In Casks	ton	54.00	57.00-62.00
Neodymium oxalate, 50 lb. drums	lb.	....	3.00
Nickel oxide (Ni_2O_3), black	lb.	....	.35-.40
Nickel monoxide (NiO), green	lb.	....	.35-.40
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals	lb.	....	.09
Powdered	lb.	....	.09½
Potassium Chromate (K_2CrO_4) 100 lb. kegs	lb.	....	.27
Powder blue	lb.	....	.18¾-.19¼
Rare earth hydrate			
100 lb. drums	lb.	....	.35
325 lb. barrels	lb.	....	.30
Selenium (Se) In 100 lb. lots	lb.	....	2.00
In lesser quantities	lb.	....	2.10
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06⅝	.07
Sodium chromate (Na_2CrO_4) Anhydrous	lb.	....	.08⅜
Sodium selenite (Na_2SeO_3)	lb.	....	1.80-2.00
Sodium uranate (Na_2UO_4) Orange	lb.	....	1.50-1.55
Yellow	lb.	....	1.50-1.55
Sodium uranyl carbonate	lb.	....	.80-.90
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb.	3.35	3.70-4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls.	Per 100 lb.	2.90	3.25-3.65
Uranium oxide (UO_2) (black, 96% U_2O_6) 100 lb. lots. Black	lb.	....	2.25
Yellow orange	lb.	....	1.50

Polishing Materials

		Carlots	Less Carlots
Emery, Turkish	lb.	....	.07
Pumice Stone,			
American Ground Italian FFF, FF, F	lb.	....	.03
0, 0½, ½, 1.	lb.	....	.03¾
Putty Powder	lb.	....	.42
Rotten Stone	lb.	....	.03
Rouge, Red	lb.	....	.14
Black	lb.	....	.16

REVIEW

Feldspar as a Constituent of Glass. A brochure edited by Donald E. Sharp and prepared by members of the staff of Bailey & Sharp Company; published by National Feldspar Association, New York; paper bound, 78 pages with 18 diagrams and numerous tables. Gratis.

This booklet is one which could well be on the desk of every glassmaker, particularly if he is interested in the introduction of alumina into his glass and wants specific information about feldspar which is apparently the most feasible and economical method for putting in this desirable oxide.

The introduction presents reliable, definite, and condensed information about feldspar. It includes the standard specifications put out by The National Bureau of Standards, and these supply handy reference material for the purchaser.

The chapter on Glass Compositions is condensed from Mr. Sharp's paper in the *Journal of Industrial and Engineering Chemistry*, 1933, which may be regarded as the best compilation as well as general discussion of glass compositions in print. The glasses are classified according to their uses; and a sufficiently large number of examples is given to present an excellent idea of the detailed compositions that are actually in use in both American and foreign factories.

Chapter Three follows very properly with instructions for calculating the composition of glass from the batch, and the batch to make a given glass, and for using cullet of somewhat different composition from the final glass desired. In this chapter, Mr. Lyle has taken pains to be clear and accurate, and has worked out a number of examples as illustrative material. There follows a chapter on typical batches which shows, according to present-day practice, what reagents are used for specific purposes in different lines of manufacture. These tabulated batches will be of particular value to glassmakers who do not care to go into the calculation methods, but who, nevertheless, may want to check up to determine whether or not their practice is in line with what may be considered desirable or standard.

The next few chapters constitute reports of research work which has been done on the influence of alumina on various properties of glass. Naturally these chapters are headed "Influence of Feldspar," but this may be condoned in an advertising booklet which is otherwise so restrained as to be scarcely recognizable as promotional material. Work such as that of Gehlhoff and Thomas on the mechanical properties; Bailey's excellent critical discussion of chemical durability; Lyle, Horak, and Sharp on chemical durability (*Journal of the American Ceramic Society*, 1936); and Horak and Sharp on devitrification (reprinted from GLASS INDUSTRY, 1936) makes up, together wth the numerous footnotes, quite a budget of information on just what may be accomplished by the addition of alumina (we mean feldspar) to glass.

A chapter on the testing of feldspar consists of material furnished by the National Bureau of Standards and sets forth these official methods for analyzing the material. While these are not exactly new to the experienced chemist, they are presented here in a very convenient form for reference, and will even be of interest to the reader who is not a chemist if he is at all curious about the labor and pains necessary to turn out a good chemical analysis. No doubt the editor and his staff are aware of better and more rapid methods for some of these determinations, notably that of lime, which most chemists are inclined to complete by titration rather than by ignition, but the point is that these are the accepted methods to be used in any disputed cases.

The booklet ends with a chapter of factors for use in composition calculations. These are carried to three decimal places and refer to chemically pure materials. It might have been well to insert a word of warning to this effect, and to advise that reference should be made to compositions as reported by the plant chemist from time to time, before precise calculations are made using the factors.

The Feldspar Association should be complimented for making this little handbook available to the industry. Its accuracy and authority may be accepted without question, in view of the standing of the editor and the authors. It is particularly to be admired because it is quite free from any statements that can be called in the least extravagant, while it does make out an excellent case for alumina as a regular constituent of glass, as well as for feldspar as a convenient source of alumina.

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POLARIZED light is so closely associated with glass, that the development of Polaroid becomes of immediate importance to the glass industry. Quite recently, at the exhibit of the American Institute of Physics, the Polarizing Instrument Company, 8 West 40th Street, New York City, showed for the first time, several instruments which were primarily developed for the glass industry. For the annual meeting of the Ceramic Society, they have brought out many new developments, several of which are listed below. In all of their developments, they have concentrated on large field inspection, the elimination of the peep hole eyepiece, ease of operation, portability, and extreme lightness of weight. Polaroid has made all of these possible.

A STRAINTESTER never before shown by them has a polarizing field of 6″ diameter and it is only 2″ deep. It weighs about two pounds. It has been designed so that it can be put into a brief case or even slipped into one's pocket. It is priced at $85.00. Although this instrument was primarily designed for the glass container field, for production inspection, or for the "trouble shooter," it fits in very nicely for any problem which can be conveniently handled with a 6″ field.

ANOTHER new development, quite similar to the one just described, has a 12″ diameter field; it is 4″ deep and weighs about five pounds. It swings in a rocker so that it can be set for any convenient angle. It is priced at $150.00.

THEN there is a straintester designed for a special requirement with a polarizing field of 8″ x 16″ and only 4″ deep. In designing these straintesters, the Polarizing Instrument Company has departed from the usual pattern whereby the examiner was obliged to hold the glassware at an angle of 45° from the horizontal. The position was unnatural. With all of these instruments, the glassware is held either horizontally or vertically. In the production department or in sales or field work, this change will be welcomed.

ALSO for a special requirement is a straintester of 10″ aperture which has been designed for the examination of diffused glass. This problem was sharply different from the usual problem of glass strain testing in that diffusing glass tends to depolarize light. To offset this characteristic, an instrument had to be designed that had maximum sensitivity. Here a directed beam of polarized light is focused at a predetermined distance from the polarizer, the examiner being at the focal point and getting the benefit of practically all the polarized light rays emanating from the light source thus resulting in extreme sensitivity. This instrument has been primarily designed for the research laboratory or such other work where absolute precision is required.

IN ceramics, it is frequently necessary to examine glazed surfaces for imperfections, color or other characteristics. The ordinary light source presents difficulties for such work since it throws off an annoying glare of reflected light which interferes with the ability to see clearly. Examination under sun light presents similar objections. The Polarizing Instrument Company has brought out a *lamp* which corrects this objectionable feature of illumination. It consists of a miniature 75 watt (110 volt AC or DC) in a special housing. A reflector back of the lamp sends all the light collected through a condensing lens and then through Polaroid, thus polarizing the light and providing non-glare illumination. The Polaroid is mounted so that it can be rotated through 180°. For more sensitive results, the observer may use polarizing spectacles in addition to the lamp. Since the plane of polarization of the polarized light source may be rotated, the lamp can be placed at almost any angle in relation to the object under examination. The lamp, plus the spectacles sells at $49.00.

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